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FROM

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SEASON 1953-54

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NAMULONGE, UGANDA

SECTIONAL REPORTS

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COTTON RESEARCH STATION, NAMULONGE

PROGRESS REPORT FOR THE SEASON 1953-54

CROP CALENDAR

	Cotton	*Food Crops*
Sowing	June-August	February-April
Flowering	September-November	—
Reaping	December-March	May-August

Introduction

BY

J. B. HUTCHINSON.

The Namulonge Advisory Board met on December 9th, 1953. Mr. J. C. May, the Director of the Corporation, was present and took the chair. All contributing territories and E.A.A.F.R.O. were represented. The meetings of the Advisory Board provide an opportunity, greatly valued at Namulonge, to discuss research problems with representatives of the Departments of Agriculture, and to ensure that we are fully aware of the ways in which our work can be directed to their advantage.

There have been considerable staff changes in the Entomology section. Mr. Geering resigned in April 1954 to take up a post in the Sudan. He is greatly missed. Mr. McKinlay, who has been a guest research worker at Namulonge for 3 years, left on transfer to Ilonga, Tanganyika. While at Namulonge he was a full member of the Namulonge team, and his departure was much regretted. By courtesy of the Director of E.A.A.F.R.O. he has contributed to the Entomological section of this report. Mr. T. M. Coaker joined the staff as an Entomologist in August 1953, but he is for the present alone in the section.

By arrangement with the British Cotton Industry Research Association, Mr. C. Underwood, who has for many years carried out spinning tests on Empire cottons, has spent a most valuable four months at Namulonge, working with the Lint Physiologist on the development of ideas and techniques of quality testing.

We have welcomed the opportunity of co-operating in the development of the Faculty of Agriculture at Makerere College. A herd of cattle, bought with an estate five miles from Namulonge, has been accommodated pending the appointment of a Manager for the College farm. Mr. Stephens has given a series of farm classes to Makerere students. In the laboratories of the Plant Pathology section a room has been lent to Dr. M. A. Keay pending the provision of accommodation for the Faculty of Agriculture at Makerere.

Visits were paid by members of the staff to the following territories:

Kenya, Nyanza.—Dr. Hutchinson.

Tanganyika, Ukiriguru.—Mr. Le Mare (3 visits), Mr. MacDonald and Mr. Geering. *Ilonga.*—Mr. Coaker.

Nyasaland.—Mr. Manning and Dr. Wickens.

Sudan.—Dr. Wickens.

Nigeria.—Dr. Wickens.

Two meetings of the Specialist Committee on Agricultural Botany were attended:—At Muguga by Dr. Hutchinson, Mr. Prentice and Mr. Manning, and at Ukiriguru by Dr. Hutchinson, Mr. Prentice and Dr. Wickens.

Mr. Coaker attended a meeting of the Specialist Committee on Entomology and Insecticides at Morogoro, Tanganyika.

The Farm

BY

A. L. STEPHENS.

The expansion of the farm has proceeded satisfactorily. A further 92 acres have been brought into use. A block of 21 acres of land which had completed three years of cropping has been put down to a grass ley, giving a nett increase of land under crops of 71 acres.

The 564 acres of Namulonge now under control consist of:—

Arable:			
	Cropped in 1953	263 acres	
	Grass ley	21 acres	
	Cleared in 1953 but not cropped	26 acres	
	Paths	34 acres	344 acres
Permanent Pasture:			
	Paddocks	45 acres	
	Fenced rough grazing	15 acres	
	Housing area (grazed)	60 acres	120 acres
Housing area (excluding area grazed but including allotments) ...			53 acres
Gum plantation			40 acres
Orchard and steading			2 acres
Meteorological station and grass plots			5 acres

The arable area, much of which was cropped twice during the year, provided 96 acres of cotton, 68 acres of first and 27 acres of second rains maize, 20 acres of first and 44 acres of second rains beans and the balance in cassava, sweet potatoes, groundnuts, and sunflower.

Of the cotton area, 68 acres were planted with breeding and multiplication stocks of BP52. Much of the multiplication area was under experimental treatments of various kinds, and in some cases the gross acreage was reduced by the uprooting of guard rows. The calculation of yields per acre from gross acreages and gross yields would therefore be inaccurate. Acreages and total yields of BP52 seed cotton over all times of planting were as follows:—

Breeding stocks	18 acres	giving 12,000 lb. seed cotton
Farm multiplication areas ...	46 acres	giving 30,000 lb. seed cotton
Rotation experiments	4 acres	giving 4,500 lb. seed cotton
Total	68 acres	giving 46,500 lb. seed cotton

The remaining cotton area comprised 9 acres under Barberton

and Albar stocks and their hybrids and 19 under miscellaneous experiments involving a range of varieties. Seed cotton from stocks other than BP52 was ginned and sold as scrap.

A shortage of labour, during the period December 1953 to March 1954 inclusive, not only delayed harvesting of the cotton but has also delayed subsequent operations considerably. While labour has never been over-plentiful at Namulonge, in the past we have usually managed to tide over bad periods by neglecting such work as planting of grass paths and the maintenance of roads, etc., without neglecting crops too much; it has now, however, become a serious limiting factor in the actual farming of Namulonge.

The problem of using maize as a first rains crop in a cotton rotation without delaying the subsequent cotton too much is considerable under our methods of farming, for whereas the African smallholder can sow his cotton between the rows of his ripening maize and overcome any time lag, our ridge cultivation precludes the use of similar methods. Thus we have to rely on an early maturing variety of maize (sacrificing some of the potential yield), planted as early as possible, and we also need to reduce the time used in land preparation between the two crops. By planting maize before the first showers of late February, nearly a month before the main rains can be expected with certainty, the time of harvesting of the maize crop is much advanced. In order to reduce the delay between crops caused by uprooting and carrying off the maize stalks before preparing the land for cotton, the old ridges were rebuilt by passing a ridging plough through the standing maize, and, after harvesting the crop, the stalks were pulled up and laid in the furrows as mulch. Apart from the saving in time, costs were reduced by the omission of one ploughing and the saving in labour normally used in carrying off the stalks. Four strips on Ginnery Slope, totalling 7·2 acres, were successfully dealt with in this manner, and mean yields of 2,600 lb. of dry maize (under 12% moisture) and 959 lb. of seed cotton per acre were harvested. The land used was newly broken up and consequently the weed growth in the maize was too heavy for the re-ridging to be completely effective in weed eradication. The cotton did not have as clean a start as it might have done, and better results may be obtainable from second or third year land.

The block of land sown down to a grass ley early in the year was used to test two methods of establishing *Chloris gayana*. On four strips the grass was sown on the old ridges, while in the other four strips the ridges were first broken down with a cultivator before sowing. On these, two systems of management were superimposed. The first consisted of dividing four strips into two paddocks, each grazed for a fortnight and rested for a fortnight; while in the second an intensive system of grazing is practised by dividing the four strips

into 28 quarter acre plots, each of which is grazed for 24 hours using an electric fence. The fourteen acres under these treatments have carried 20 bullocks and yielded a live-weight increase of 0·53 lb. per beast per day.

The cattle, apart from natural increase, have been supplemented by the purchase of eleven culls and four bull calves from the Veterinary Research Farm at Entebbe. These bull calves are progeny of some of the best milking stock at Entebbe, and should provide Namulonge with at least one good herd bull. The culls were bought in order to swell the numbers of the ranged herd. The herd position in March 1954 was that we had 68 cows, 37 heifers, 2 bulls, 38 bullocks and young bulls and 60 calves, but the cows include a large number of culls and so far we have only eight which appear to be good enough milkers for inclusion in our eventual breeding herd. Since June 1953, we have also looked after a herd of 60 head of cattle belonging to Makerere College, and, with these to boost up the milk production, we have at last succeeded in meeting the staff demand for milk and have made between 100 and 130 lb. of butter per month.

Owing to the increased cropping programme storage space became short and so the capacity of both the main produce stores is being increased considerably by the erection of lofts. With the rapid increase in the number of calves the temporary buildings in which they were housed soon became inadequate and a system of individual housing was adopted using portable aluminium houses made on the farm. These are moved daily and so save labour of cleaning out and providing bedding. Other building projects completed during the year consist of a shed for the threshing machine, a spray crush for the cattle and an insect proof house at the laboratory.

Climatology

BY

H. L. MANNING AND H. G. FARBROTHER.

Standard meteorological data are summarised in Table 1 firstly for the cotton growing season and secondly for the food crop season. Sufficient rainfall data have now been accumulated for this area to show that it should be possible, in three years out of four, to establish food crops such as maize during the third week in February. This is a saving of nearly five weeks on the average date (March 31st) of sowing maize during the past 22 years at Bukalasa on the continuous cultivation experiment. Reference to the section on the Farm for this and past seasons will show that such early sowings have actually led to very satisfactory maize yields. With a crop whose growing period is of the order of 120 days, it will be seen that this early saving enables the farmer to reap his maize in time to sow cotton near the optimum sowing date, which is estimated for this area to be about June 21st.

TABLE 1.

SUMMARY OF METEOROLOGICAL DATA FOR 1953-54.

Month	Rainfall		Open Pan Evaporation		Relative Humidity		Sunshine		Air Temperature °F.		
	Ins.	Days >0·01	Standard	Recording	a.m.	p.m.	C.S. (hrs.)	Call. (units)	Max.	Min.	Average.
June	2·76	11	4·46	3·72	85·7	60·6	6·0	647	81·0	61·6	71·3
July	0·64	4	5·66	4·79	78·2	50·7	6·8	677	80·9	57·8	69·3
August	4·49	12	5·18	4·16	83·5	57·5	4·8	602	81·6	61·4	71·5
September	7·13	10	5·29	4·26	82·0	57·8	5·9	752	81·6	60·7	71·1
October	5·04	18	6·36	5·21	79·3	56·7	6·3	788	82·9	62·3	72·6
November	6·27	16	6·09	4·29	77·1	57·0	6·7	754	83·2	62·8	73·0
December	6·61	11	6·02	4·45	76·3	50·5	7·7	776	83·7	60·5	72·1
January	1·10	4	6·44	5·91	78·3	38·4	8·0	798	86·0	58·5	72·2
Sums	34·04	86	45·50	36·79	640·4	429·2	52·2	5794	660·9	485·6	573·1
Means	—	—	—	—	80·0	53·6	6·5	724	82·6	60·7	71·6
February	2·61	6	6·83	5·46	76·1	43·0	7·5	804	86·7	60·8	73·7
March	3·81	12	7·47	5·64	76·9	49·6	6·8	748	86·1	62·9	74·5
April	5·22	19	5·77	3·88	83·0	62·1	5·6	692	81·7	63·8	72·7
May	5·41	18	5·54	3·58	84·0	65·1	5·8	664	81·1	62·6	71·8
Sums	17·05	55	25·61	18·56	320·0	219·8	25·7	2908	335·6	250·1	292·7
Means	—	—	—	—	80·0	54·9	6·4	727	83·9	62·5	73·2
Annual Totals	51·09	141	71·11	55·35	—	—	—	—	—	—	—
Means	—	—	—	—	80·0	54·1	6·5	725	83·0	61·3	72·1

TABLE 2.

SEED COTTON YIELDS PER ACRE OF BP52 STRAINS AT NAMULONGE.
ACREAGES FOR MEAN YIELDS IN PARENTHESES.

Sowing Period	1950-51 First rains 23·46"		1951-52 First rains 26·65"		1952-53 First rains 17·83"		First rains 14·17" 1953-54	
	Yield p.a.	Per cent June 1-15	Yield p.a.	Per cent June 1-15	Yield p.a.	Per cent June 1-15	Yield p.a.	Per cent June 1-15
June 1-15	961 (3·0)	100	1150 (1·1)	100	920 (3·9)	100	965 (9·8)	100
June 16-30	—	—	1163 (5·4)	101	983 (3·2)	107	975 (8·4)	101
July 1-15	582 (3·8)	61	1072 (0·4)	98	1015 (3·8)	110	—	—
July 16-31	575 (5·4)	60	1145 (1·2)	100	679 (1·4)	74	—	—
August 1-15	474 (3·4)	49	831 (1·7)	72	562 (7·7)	61	756 (7·0)	78
August 16-31	—	—	772 (1·4)	67	277 (5·2)	30	—	—

Reference to Table 1 shows that for this cotton season rainfall during the second half of the calendar year was unusually favourable. Indeed, the total rainfall for the four months September to December amounted to 25·05 inches. This total was the second highest on record for the period, and undoubtedly favoured the later sowings of cotton. On the other hand germination and early crop establishment, particularly for the July sowings, presented some difficulty. Apart from a formal sowing date trial no cotton was sown in July, for which the monthly rainfall was only 0·64 inches.

Seed cotton yields of BP52 material for the past four seasons are summarised in Table 2. Even with the unusually favourable post-sowing conditions the mid August sown cotton yielded some 20 per cent less than the timely sown cotton in June. A drop of about 20 per cent from early June to early August sowing represented experience over most of the farm. In some experiments, August sown plots yielded well (see Crop Husbandry), but the bulks from 7 acres were only slightly better than the four year average for that date. Thus the decline persists as a major factor each season superimposed upon the quite considerable seasonal variations of both pre-sowing and post-sowing rainfall. Evidently there is much to be learnt before crop water requirements can be specified, or the role of water reserves in the soil profile understood.

Of the information arising from climatological observations entailed in the study of crop water requirements, that provided by the temperature-compensated recording evaporimeter is of particular interest. Records were compared with those from the standard hydrological pattern on raised timber balks, a pattern of which there are many in East Africa. Data over 15 months are now available to demonstrate that this evaporimeter, and indeed many other evaporimeters, are subject to quite considerable errors when allowing for the amount of rain on rainy days. It has been assumed in the absence of evidence to the contrary, that a simple deduction of the amount of rain recorded in the raingauge will provide a satisfactory correction for rainfall in the estimate of the day's evaporation. However, the recording evaporimeter, by virtue of its record of the actual accretion from rainfall and its instantaneous recommencement of the record after a fall of rain, has shown that this adjustment is far from simple. The records indicate that there is a differential splash in and out of the evaporimeter which varies with differences in rainfall intensity. This error is reduced where the evaporimeter is provided with a water jacket. The hydrological pattern, being without such a jacket, is subject to considerable error on rainy days. Referring to Table 1, over the two seasons there were 141 days with rain >0·01 inches. During the period the recording evaporimeter provided an

estimate for total evaporation of 55·35 inches. During the same period that from the hydrological pattern was 71·11 inches.

Since an estimate of free water surface evaporation is of fundamental importance to the study of crop water requirements, it is clearly desirable to have available a method of adjusting past records of the hydrological pattern. Under climatic conditions at Namulonge a correlation surface for days without rain shows reasonably close agreement between the two evaporimeters. On rainy days, however, the hydrological pattern shows an average excess of 0·085 inches. Using this correction the hydrological pattern would then give an estimate of 59·13 inches compared with the 55·35 inches during the 12 months period.

Crop Husbandry

BY

A. N. PRENTICE.

Rotation Trials.

The trials grouped under the general heading "Rotation" have now all got under way. Of the five series mentioned last year some were modified or recast and a sixth series, essentially to test the best crop (of four) to follow grass, was added. The modifications were largely based on very helpful criticisms from the late Dr. E. M. Crowther, and were partly changes in the physical lay-out of trials to allow of complete and independent mechanisation of plots.

The Series 1 trial had a full year's crops. This comparatively simple trial of four first rains treatments, followed by an indicator crop of cotton, gave good yields. The small quick-maturing K8 variety of maize averaged over 2,800 pounds per acre of dry grain, and the legume crop yields were satisfactory. The two other first rains treatments were bare fallow, and sunnhemp cut young and laid as a mulch. These two treatments were made into split plots at the time of planting cotton; the overriding advantages to be gained from such otherwise unproductive handling as bare fallowing are timely planting of cotton and greater accumulation of moisture reserves, and the "early" halves of such plots therefore were planted at about the optimum time, actually 17th June 1953. The remaining half-plots were planted with the post maize plots on 10th August 1953, a late planting of cotton by Namulonge standards. Considering the strictly valid time-of-planting comparisons, yields in lb. per acre seed cotton were:—

	Post Bare Fallow	Post Sunn-Hemp	Mean
Early	1,090	1,190	1,140
Late	945	952	948
Difference	145	238	192

The 192 lb. difference in the last column is highly significant, yet is unexpectedly small on previous experience. For late treatments only, yields were: —

	lb. per acre seed cotton
Post maize (2 × 6 plots)	1,112
Post legume crop (2 × 6 plots)	1,029
Post sunnhemp (6 plots) as before	952
Post bare fallow (6 plots) as before	945
Mean (not weighted)	1,009

Post maize was significantly superior to post sunnhemp and post bare fallow. Apparently for this particular season and land, intensive arable pre-cropping led to slightly better subsequent "late" cotton yields than "unexploitive" single-crop farming, and this yield benefit was nearly as great as that to be gained by early as opposed to late cotton planting in the single-cropping group. Double-cropping in its very nature precludes really early planting of cotton, so that the comparison of cotton times-of-planting is hardly possible as between the two intensities of cropping. Bare fallowing followed by early cotton, however, was actually outyielded by late cotton after maize.

The only other trial in the Rotation group to give some information this season was Series 5, another comparatively simple succession-effect trial. This bore out the general yield story from Series 1. Maize yields in the first rains were again satisfactory at 2,400 lb. dry grain to the acre. The cotton indicator crop of the second rains yielded in lb. per acre: —

Treatment	*Seed cotton*
Interplanted in maize 18.6.53: maize stooked 24.7.53 ...	1,401
Following maize—planted 11.8.53	1,381
Following fallow—planted 11.8.53	1,116
Following fallow—planted 11.8.53	1,185

Differences were not significant.

The absolute cotton yield of the control treatment, maize-cotton—1,380 lb. per acre—is quite exceptionally high for an August planting.

The June interplanted cotton hung fire badly until the maize was removed, and then recovered well but could not outyield the post maize cotton. The two fallow treatments—waiting for the trial to get into its stride before eventual root-crop planting—were virtually bare fallowed and gave yields in agreement with those of similar treatments in Series 1, suggesting that fallowing had an adverse effect this season.

The cotton strain in these trials was NC52/2, a BP52 multi-line strain which ginned in bulk at 32%. Its cropping under late planting was very satisfactory. All seed was soaked in water for 24 hours before planting to assist establishment, and stand was excellent.

Cultivation Methods.

On the Permanent Cultivation Experiment there was no difference between flat and tie-ridged methods of cultivation in the final yield of seed cotton, a lead by tie-ridged on the early pickings being made up by flat on the late pickings. Trials elsewhere on the farm with beans and maize showed little difference between yields under the two methods. A second rains crop of maize, averaging just under 3,000 lb. of dry grain per acre, showed a 15% advantage to tie-ridging which however was probably partly due to greater weediness in the flat plots. This greater weediness was due to cultivation difficulties inherent in the experimental design and not to flat cultivation *per se*.

In the Permanent Cultivation area, catchment devices are now being installed to measure loss of run-off water and silt. Crude measurements of silt in the uncompleted installations show a loss of the order of a ton an acre a month from a $\frac{1}{4}$ acre "flat" plot, no great absolute amount but consisting of the finest soil.

It was mentioned last year that the Permanent Cultivation area was heavily infected with *Verticillium* wilt. This season, three of the four acres were put under wilt resistant cottons but even in the fourth acre, under the wilt-susceptible MU8 × BP52[2], *Verticillium* attack was very mild, and the yield of 756 lb. of seed cotton was actually some 30% ahead of the next group, some wilt resistant B 181 hybrids, which gave 573 lb. per acre. The area was all planted early, in June, but bacterial blight was severe, bollworm attack was long continued, *Lygus* was damaging, and stainer was severe towards the end of the season. The well-grown plants carried much less than the framework justified. An acre of wilt resistant Acala provided a striking example of the importance of growing adapted strains: Acala was quite out of its environment, suffered appreciably from jassid as well as from the other restraints on yield, and finally totalled 170 lb. of seed cotton over the acre. The African Uplands have travelled a long way from their American Upland cousins.

In the non-cotton season of the year the Permanent Cultivation area is handled so as to give beans versus weed fallow in fourfold acre blocks. There can be no such treatment as literally continuous annual cotton in this climate as at least a weed fallow (or, artificially, a bare fallow) must intervene in the other rainy season of the twelve months. The weed fallow, now mainly of grasses such as *Panicum maximum*, is much more laborious to handle than the post bean plots, but has shown a trend to slightly higher cotton yields in the past two years.

Maize Work.

Maize yielded well in both rains of the year. In the second rains, in spite of apparently heavy infestation by stalk borer on young maize, yields reached 3,600 lb. per acre of dry grain on some bulk crops of a yellow maize "Ulu". "Ulu", generally similar to the stock "Yellow Coast" of Namulonge, has shown up as the better in trials, and is now displacing Yellow Coast on the farm and being brought into the breeding techniques study. Namulonge is interested in maize as a food supply for its labourers and of course as a rotation crop for cotton. Maize has to be watched, as a source of American bollworm, but it has come very much to the fore as a cash crop in Buganda in the last year or two, and there seems little doubt that it has come to stay.

Miscellaneous.

An Ilonga strain of cotton, 47/10, was not good in the field when grown at Namulonge, suffering badly from bacterial blight and also from jassid. A Lake Province strain, however, still extant at Ukiriguru as 7/367 and descended from the Mz.457 line, has good jassid resistance, and good lint and field qualities generally at Namulonge except for susceptibility to bacterial blight; the cross with Albar 51 shows distinct promise in the field in the first generation.

Soil Fertility Studies

BY

P. H. LE MARE.

Work has been largely in the field, and considerable attention has been given to studies of the development of the cotton crop under various experimental treatments.

Maize.

In March 1953 a field experiment was put down to determine the effect of time of planting maize on the response to nitrogen applied as sulphate of ammonia. It was thought that the generally lower yields

from late planting might in part be due to the loss of soluble nitrogen from the upper layers of the soil by leaching during the early rains, and that the earlier plantings were able to obtain this nitrogen before it was leached out of root range. The experiment was designed to test the effect of nitrogen on maize planted at four ten-day intervals. Phosphorus was also included as a treatment since the NP interaction has been shown to be of great importance with maize in many parts of East Africa. Details of treatments and layout were as follows:—

Planting dates:	March 6 and March 26. April 10 and April 20.
Nitrogen:	0 and 1 cwt. N per acre as sulphate of ammonia, applied in 2 equal dressings, (a) when the plants were 2′ high and (b) one month later.
Phosphorus:	0 and ½ cwt. P per acre as triple superphosphate placed 3½″ to the side and 2″ below the seed at time of planting.
Variety:	Muratha, planted 18″ × 36″.
Design:	4×2^2 in 4 blocks of 8 plots each.

Data on yield and plant number are given in Table 3.

Table 3.

Effect of time of planting, nitrogen and phosphorus on yield and plant number of maize, Nalumuli, 1953.

Date of Planting:	*6th Mar.*	*26th Mar.*	*10th April*	*20th April*	*Mean.*
Grain, lb./acre.					
N and P absent	2800	2074	2005	1521	2100
N alone	2697	2074	2074	1279	2031
P alone	2593	1867	2143	1348	1988
N and P together	3146	2385	1763	1625	2230
Mean	2809	2100	1997	1443	2087
Plant Number, 000/acre.					
N and P absent	9·4	5·6	9·3	7·7	8·0
N alone	8·7	6·5	9·9	9·7	8·7
P alone	7·9	6·0	10·3	10·3	8·6
N and P together	9·6	7·6	9·6	8·2	8·7
Mean	8·9	6·4	9·8	9·0	8·5

	Yield		*Plant No.*	
	Individual Treatments	*Treatment Means*	*Individual Treatments*	*Treatment Means*
S.E.	±185·6	±92·8	±0·86	±0·43
Sign. Diff., 5%	556	278	2·6	1·3
Sign. Diff., 1%	766	383	3·6	1·8

The major effects were due to time of planting, the yield decreasing progressively from 2,800 lb. grain per acre from the earliest to 1,400 lb. at the latest date. The plant population at the second date of planting was low, only 6,400 plants per acre, but the yield was a little higher than that given by the third planting. At the first two plantings N

and P together gave an increase of 300 lb. grain per acre. Given alone neither N nor P was effective and there was no response with the later plantings. There was no suggestion that the drop in yield of later plantings was due to inadequacy of nitrogen supplies.

The land on which the experiment was carried out had been ploughed out of grass in 1952, and as yet there is no evidence of gross N or P deficiency in land recently ploughed from grass. The advantages of early plantings are, however, beyond doubt.

Cotton.

To obtain a preliminary view of soil fertility conditions under cotton a 2^5 exploratory experiment was laid down. This was on land which was ploughed out of grass in 1951 and which had been planted to cassava in 1952. The five treatment comparisons in the factorial design were as follows: —

Date of clearing cassava (C):
C_0: Mid March. After clearing the land was kept clean weeded and tie-ridged.
C_1: End of May.

Time of planting (T):
T_0: 13th June.
T_1: 10th August.
The late planting was a month later than intended owing to dry weather.

Spacing (S):
S_0: 16 inches within rows.
S_1: 32 inches within rows.
Both spacings were on 3 foot ridges: two plants per hole.

Nitrogen (N):
N_0: None.
N_1: 1 cwt. N per acre as sulphate of ammonia.
N was applied in three doses each of 0·33 cwt. For the first planting, which made poor growth during the dry month of July, the first application of N was two months after planting. For the second planting, which made good early growth, the first application of N was one month after planting. The second and third dressings were at monthly intervals after the first. The fertilizer was applied on top of the ridge in drills between the plants.

Phosphorus (P):
P_0: None.
P_1: 0·5 cwt. P as triple superphosphate.
P was applied at time of planting approximately 2 inches below and 3½ inches to the side of the seed.

Design: 2^5 factorial in 4 blocks of 8 plots each.
The CSP, TSN and CTNP interactions were confounded with block differences.

Variety: MU8 × BP52[2].

Establishment of both plantings was good, though growth of the first was checked by dry weather in July. Thereafter rainfall was satisfactory and well distributed. A total of 33 inches fell between 1st June and 31st December. The yield data, as lb. seed cotton per acre, flower and boll numbers and the ratio of flowers to bolls are presented in Table 4.

Table 4.

Effects of date of removing previous crop, time of planting, spacing, nitrogen and phosphorus on yield, flower production, boll production and flower-boll ratio of cotton, Sendusu, 1953.

	Seed Cotton lb./acre	*Total flowers per sq. yd.*	*Total bolls per sq. yd.*	*Total flowers Total bolls*
Mean	793	58.4	21·1	2·84
Main effects	(± 51·6)	(± 3·25)	(±1·58)	(±0·118)
C	− 58	− 2·3	−1·5	+0·16
T	−253	+ 1·8	−3·9	+0·60
S	− 49	−14·1	−4·8	+0·05
N	+ 92	+ 5·8	+2·5	−0·09
P	+191	+12·3	+6·5	−0·28
Interactions:				
CT	+ 46	+ 3·5	+0·4	+0·10
CS	+ 16	+ 1·5	+1·0	+0·01
TS	− 86	− 2·4	−2·0	+0·22
CN	+ 50	− 5·1	−0·3	−0·23
TN	+ 6	+ 0·3	0·0	−0·11
SN	− 28	− 4·2	+0·3	−0·19
CP	− 22	− 0·4	−0·2	−0·05
TP	− 39	− 2·2	−2·2	+0·08
SP	+ 8	+ 0·4	0·0	−0·01
NP	+ 58	+ 1·4	+0·4	+0·07
Significant effects and interactions:				
5%	111	7·0	3·4	0·26
1%	155	9·8	4·8	0·36

The mean yield for the whole experiment was nearly 800 lb. seed cotton per acre. There was little effect on yield due to time of clearing of the previous crop, cassava. Early planting gave 250 lb. more seed cotton than did late planting. Overall there was little effect of spacing but the negative TS interaction indicates that late planting was compensated by closer spacing. When the NP interaction is taken into account, there were increases of 30 lb. seed cotton from N alone, 130 lb. from P alone and 280 lb. from N and P together.

The numbers of flowers and bolls per square yard were reduced by wide spacing. This might have been expected but it is interesting to note that the reduction in boll numbers is much greater, by comparison with the overall mean, than was the final reduction in yield due to wide spacing. This may have been caused either by boll shedding during the picking period or by the closer spacing having produced smaller bolls.

Phosphorus increased the number of flowers produced and the proportion of flowers that set bolls, the differences being significant.

At monthly intervals during the season soil samples were taken from the plots for nitrate estimations. On each occasion samples were taken from 0-6, 6-12 and 12-18 inches.

Plants supplied with phosphorus made a far heavier demand on soil nitrate supplies than did plants without added P. This was

noticeable throughout the season but was most marked in the final sampling at the end of December. The data for the final sampling are presented in Table 5.

TABLE 5.

SOIL NITRATE STATUS UNDER COTTON IN THE ABSENCE AND PRESENCE OF ADDED NITROGEN AND PHOSPHORUS, PPM N IN OVEN DRY SOIL, END OF DECEMBER 1953.

	Sample depth, inches.			
	0-6	*6-12*	*12-18*	*Mean*
N and P absent	2·0	2·4	14·9	6·4
N alone	46·2	37·5	34·9	39·5
P alone	1·4	1·7	7·7	3·6
N and P together	27·6	27·6	29·7	29·3

When N was not given, the values in 0-6 and 6-12 inch layers were similar whether or not P was given, though the values were slightly lower in the presence of P. In the 12-18 inch layer however, the NO_3 concentration was 15 ppm N in the absence of P and only 8 ppm in the presence of P.

Where fertiliser nitrogen had been given, nitrate concentrations were generally greater but the reduction due to the addition of phosphorus was also greater. The mean reduction over 0-18 inches due to the presence of P was from 40 to 28 ppm N, where N had been given, compared with a reduction from 6 to 4 ppm N without added nitrogen.

Although the NP interaction for yield of seed cotton was not significant, the soil nitrate data support the view that added nitrogen is of little value alone but is of importance in the presence of added phosphorus.

Effect of Mulching and Nitrogen on Cotton.

A small preliminary investigation was made of the effect of mulching and its interaction with nitrogen. Experimental details were as follows:—

Nitrogen: 0 and 1 cwt. N per acre applied in 2 equal dressings on 17th September and 23rd November. Plots split to allow comparison of sulphate of ammonia and nitrate of soda.

Mulch: Nothing vs. maize stalks from the previous crop laid in the furrows.

Design: 2^2 factorial with split plots. Planted with NC 52/2 cotton in mid August on land opened from grass late in 1952.

The difference in yield between sulphate of ammonia and nitrate of soda was only 22 lb., the yields being 952 and 974 lb. seed cotton per acre. The data for nitrogen and mulch, using the means of the two forms of nitrogen, are presented in Table 6.

Table 6.

Effect of mulch and nitrogen on yield of cotton, Kigalama. Seed Cotton, lb. per acre.

Mean yield	945
Effect of nitrogen	38 (±57·1)
Effect of mulch	50
Nitrogen × mulch interaction	−127
Significant effects and interaction 5% ...	129

The main effects of nitrogen and mulch were small, but there was a negative interaction so that the responses to nitrogen alone and to mulch alone were about 170 lb. seed cotton in each case. They approached significance at the 5% level.

Plant Physiology

by

H. G. Farbrother.

Growth and Development of the Cotton Plant.

Detailed records have again been taken on the growth of early and late planted BP52.5MB. The Communal Experiment (see Review of Research Programme) was used as the source of material, providing six comparisons (three localities and two times of planting) towards the analysis of growth in relation to climatic factors which is the long-term object of this plant physiological work. The basic records for this year are shown in Figs. 1 to 5 and may be compared with their counterparts for 1951-52 and 1952-53 which appeared in previous reports.

The environment this year provided a long and protracted season, effective boll setting being spread over the months September to early January, and picking from mid December to mid March. The continuation of the rains into late December together with the dry conditions of June and July might have been expected to minimise the differences in yield levels between the early plantings of June 9th and the late plantings of August. This was not so however, the yields of seed cotton per acre in this experiment being 915 lb. for the early and 627 lb. for the late plantings, a reduction of about 30 per cent.

From the physiological point of view, the interest this year centres on the failure of the late plantings to take advantage of the unusually extended growing season. The analysis of numbers of bolls produced shows that the total of all full-sized bolls fell only from 18·0 to 16·9 per plant from early to late. Of these, the numbers damaged amounted to 34·7% for the late plantings, and 29·2% for the early plantings, giving a nett comparison of 12·7 good bolls per plant from early plantings, and 11·0 from late plantings, or a drop of 13 per cent.

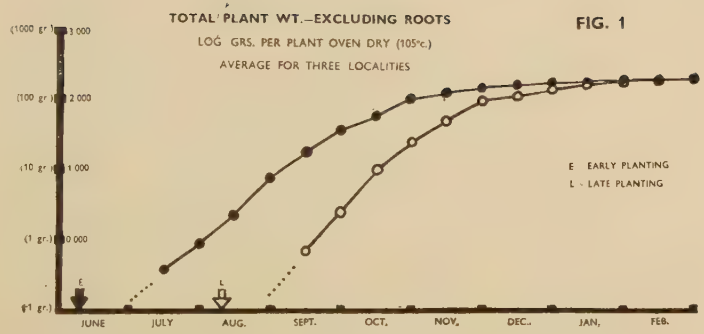

FIG. 1

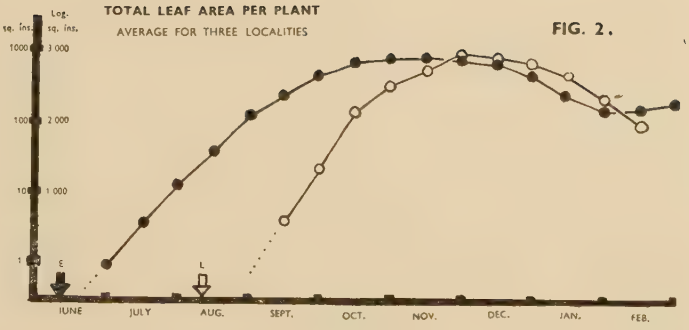

FIG. 2.

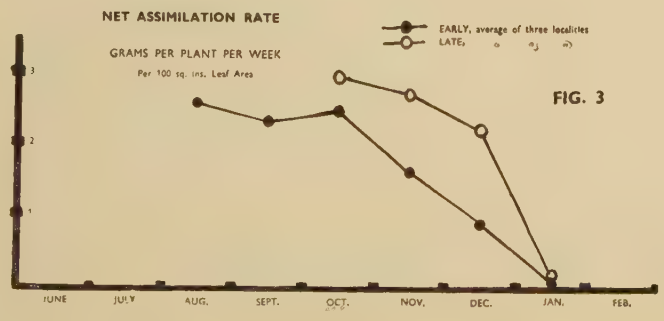

FIG. 3

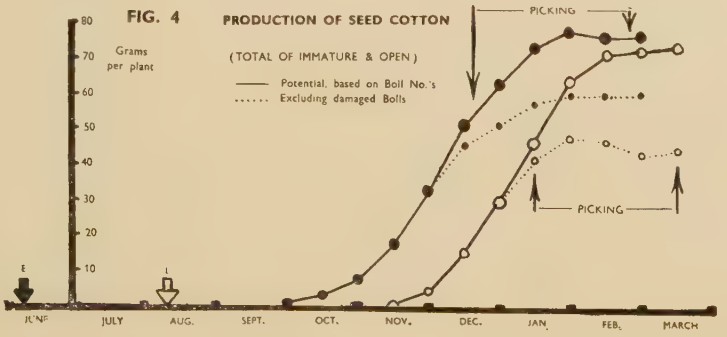

FIG. 4

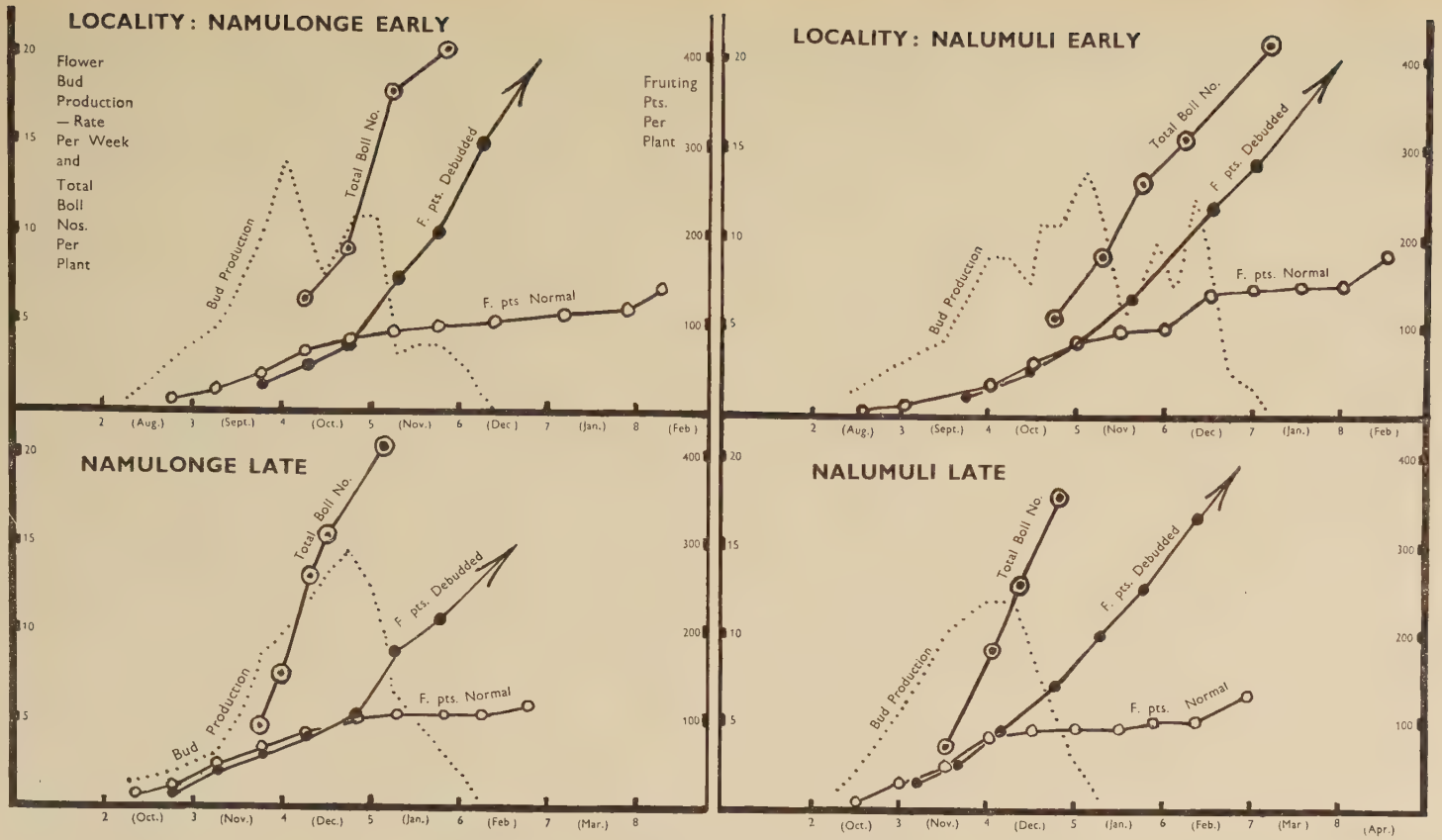

FIG. 5 Months After Planting

Using boll numbers and the average boll weight as recorded for each locality, it is possible to calculate the potential yield levels which would have been obtained in the absence of damage. These values, together with the actual yield and other figures provided by the Entomology Section from their part of the Communal Experiment, are given in Table 7.

TABLE 7.

YIELDS OF SEED COTTON IN LB. PER ACRE FROM COMMUNAL EXPERIMENT.

Source of Data	*Early*	*Late*
Entomologists' "Best" Treatment*, actual	1,313	996
"Potential" yield of Control Plots	1,079	1,002
Entomologists' Control Plots, actual	999	641
Actual yields, all plots	915	627

*The entomologists' treatments were variations in the dates of protection from insect pests. The "best" treatment has been used here irrespective of the actual dates of application, which have varied with locality. Fig. 5 shows the variation in physiological age between two localities for the control plants. Results of protection from insects by localities must clearly be averaged with respect to physiological age and stage of development rather than calendar date.

For the late plantings it will be seen that the entomologists' "best" and the "potential" yield are similar, and both are considerably higher than the other values. Considering that the former is actual protection from pests and that the latter compensates for all late damage to seed cotton, it does appear, on the evidence available, that loss of semi-mature bolls has been largely responsible for bringing down the yield into line with forecast values based on time of planting.

For the early plantings, the entomologists' "best" is well above the "potential" and other estimates of yield: assuming this large difference to be real, it is reasonable to suggest that protection from insects influenced the actual setting of a larger crop rather than merely the preservation of bolls once set.

Growth of Debudded Plants.

A study on debudded plants was carried out within the same six cotton plots of the Communal Experiment. 50 average plants per plot were labelled in August and September and all flower buds were removed and counted at intervals until the end of the season. These debudded plants were later withdrawn from the field and the routine measurements of oven-dry weight, fruiting point counts, leaf area, etc., were made for comparison with control plants. The actual cumulative totals of buds removed agree tolerably well with fruiting point counts when finally withdrawn from the field, though some "matchhead" bud shedding in January led to slightly lower totals for

buds removed. But it is permissible, with that reservation, to use bud production to represent fruiting point production for purposes of comparison with fruiting point production on control plants.

Figure 5 shows these estimates of fruiting point production for two localities at the two dates of planting. Superimposed on the graphs are the rates of bud production and the cumulative totals of bolls per plant for normal plants. The date at which the two fruiting point curves begin to diverge must in each case be a most critical characteristic of the particular crop, for it indicates precisely the date when internal factors, stimulated by weight of crop, have begun to limit the development of the fruiting structure of the plant.

The interest attached to this date is, of course, in its relation to the vegetative growth achieved by the plant up to that time; leaf area, monopodial growth, rooting development, for example. A date for the onset of this divergence before the establishment of a generous vegetative structure would imply the subsequent risk of insufficient synthesised carbohydrates to carry the crop through to maturity. On the other hand, an optimum date would be such that by that time a large enough plant structure had become available to carry the bigger crop safely through to maturity. Finally, a post-optimum date suggests a cut-off in fruiting due to external factors, particularly those connected with the end of the season, such as drought or extremes of temperature. Thus it is claimed that the physiological age of a crop can now be related to its actual age at a particularly relevant stage of development, the point where control of development of fruiting points is transferred from external to internal factors.

"Matchhead" Shedding of Flower Buds.

"Matchhead" shedding, first described in last year's report, has been followed during this season, again on the six main comparisons of the Communal Experiment. The growing points of all sympodia on small samples of randomly chosen plants were examined for abscission of the youngest visible flower bud (i.e. at the "matchhead" bud stage, some 1-3 mms. in diameter). This was carried out at intervals throughout the season. The results are shown in Table 8, condensed into monthly values.

Table 8.

	No. of sympodia examined.	*"Matchhead" buds.*		*Vegetative buds shed.*
		Present.	*Absent.*	
September	64	62	0	2
October	—	33	7	(No record)
November	54	31	17	6
December	107	43	43	21
January	85	3	23	59
February	64	20*	5	39

*Due to flush of new growth.

These figures show that there has been no clear cut date for the onset of shedding such as was so marked in 1952-53. The January total of young buds present is admittedly much below that for December but it is coupled with a three-fold increase in the occurrence of abscission of the vegetative bud terminating extension of the sympodium.

The debudded plants, referred to earlier in this report, were also examined for "matchhead" bud shedding. Only during the month mid January to mid February did shedding occur on these plants. The highest observed ratio of buds shed to not-shed was recorded on 25th January when the actual counts were 211 shed and 13 not-shed (totals for 5 plants). Clearly, with no buds, flowers or bolls, the influence of the crop could not be a relevant factor, and the cause must be looked for among the environmental factors at that time. The period coincides with the period during which relative turgidity fell below 85%. As values of approximately 70% relative turgidity represent conditions at wilting point, this means that considerable water stress was being exhibited by the plants. Both before and after this particular period relative turgidities were well maintained between 90% and 100%. There is thus evidence this year that water strain, or perhaps more correctly, the environment resulting in water strain, was related to "matchhead" shedding. The drought of January could hardly be said to have been severe, but it did form a distinct contrast with the previous five months of the season, and so it appears that the suddenness of change might be responsible for the very effective limitation on bud development during this period.

Field Use of Nylon Resistance Units for Recording Soil Moisture.

Work continues on the development of the Nylon unit. The use of a hydraulic press to standardise the pressure used in assembling the units has materially improved the consistency of results. The effect of the physical texture of the soil on calibration of the units is still under study. Synthetic soil conditioners hold promise for use in laboratory calibration, while for field calibration, techniques for placing the units in the soil are being compared. These units have been introduced into the Communal Experiment on a modest scale this year; 120 units have been deployed in 12 profiles of 10 each, one at every foot depth to 10 ft. The profiles have been sited at 3 per acre as a first instalment towards the 10 per acre considered to be necessary to overcome inherent variations in sub-soil moistures. The agreement between profiles nevertheless has been most promising.

The data show that the balance of available water held by the top five feet of soil began to fall in late October and was not offset by the considerable subsequent rainfall. In all profiles but one there was

no material change in soil moisture tension below 5 feet; this depth can therefore be regarded as the limit of effective rooting depth for this particular experiment, in this season.

Unfortunately the pattern of rainfall this year has not been favourable for the quantitative measurement of consumptive use of water by the crop, there having been an excess of rainfall over estimated evapo-transpiration, giving a wetting profile with an undetermined amount of drainage below the 10 ft. depth.

Lint Physiology

BY

J. P. EVENSON.

Fibre Tests on 1952-53 Experiments.

The changes in seed weight and lint index shown to occur (1951-52 season) from early to late formed bolls in the same crop were again observed under the very dry conditions of 1952-53 season. The range of seed weights remained similar, being high in the early bolls of the crop and low in the late. Lint samples were again sent for fibre test at the Shirley Institute. Changes in fibre character, however, differed from the previous season. Values for mean fibre weight (H) and maturity ratios (M) showed little tendency to fall at the end of the cropping period (c.f. 1952-53 Progress Report) presumably in consequence of the dry sunny conditions prevailing at the end of the season. Effective length (E) of the lint, on the other hand, fell off in the later bolls, demonstrating the change in staple that may be expected from the late bolls of late plantings in a dry season. Data are given in Table 9.

Table 9.

Fibre characters from dated boll series in 1952-53 season.

Strain	*3MB*			*S47*			*MU8 & BP52²*		
Flowering date.	*E*	*M*	*H*	*E*	*M*	*H*	*E*	*M*	*H*
23.10 - 1.11	43	0·79	133	42	0·815	142	41	0·765	132
2.11 - 8.11	41	0·765	129	40	0·745	134	39	0·77	138
9.11 - 15.11	39	0·75	127	40	0·74	137	38	0·72	123
16.11 - 22.11	36	0·82	134	36	0·805	144	34	0·725	130
23.11 - 28.11	36	0·80	145	34	0·82	150	33	0·79	134
29.11 - 2.12	—	—	—	35	0·905	151	36	0·785	135

Neppiness.

Further progress has been made in studies of seed coat nep and tests have now shown that this type of nep is often an important factor in the yarn appearance of East African cottons. It seems that in terms of the damaged seed count (Evenson 1951-52), damage rates of less

than 20% may be considered satisfactory. All Uganda strains likely to be prone to this weakness are now examined in this manner.

Work has continued on the distribution of immature hairs about the seed and this has been greatly helped by the introduction of a method of estimating MH or M^2H_s (where M = Maturity ratio, H = Mean hair weight/cm, and H_s = Standard hair weight). Using an air flow technique similar to that of the "Micronaire", a simple apparatus has been set up which measures accurately the resistance of plugs of lint of known weight (50 mgms) to a flow of air under fixed pressure. The apparatus, details of which will be published elsewhere, is not expensive to set up and is simple to operate. In a series of tests on cotton samples already tested by Shirley Institute the regression of air flow rate on M^2H calculated from Shirley Tests gave $r = + 0{\cdot}914$ and $R^2 = 0{\cdot}836$ or 83%. The test is rapid and requires little technical skill.

In order to test the validity of the theories put forward in last year's report concerning the importance of chalazal immaturity in the tangled nep problem, work is now in progress using the airflow method on the strain to strain variation in airflow value of chalazal lint (C), compared with that of the rest of the lint on the seed (R), to discover to what extent variation in the value R-C or $\frac{R}{C}$ varies from season to season and within season from strain to strain. In addition to this, material will be sent to the Shirley Institute for spinning test to discover what effect variation in the values of C for constant values of R has on the neppiness of yarn.

Entomology

BY

Q. A. GEERING, K. S. MCKINLAY AND T. H. COAKER.

Lygus Field Studies, and Estimation of Crop Loss from Insects.

Records of *Lygus* were made on *Pseudarthria sp.*, a wild perennial leguminous herb, and on peasant plots of sorghum and gram. *Pseudarthria* commenced flowering in the first week of June, and continued until mid December with a prolonged peak of flowering during August and September. The changes in *Lygus* population followed this closely. All colonies of the host were destroyed by fire in early January. Plots of sorghum and gram were sampled by sweeping during June and July. These showed *Lygus vosseleri* breeding continuously, reaching peak numbers on each crop 2 weeks before harvest. On sorghum, counts were obtained by shaking heads into a sweeping net, and numbers reached a maximum of 119 per 110 heads (17,000 per acre) in mid July. Numbers then declined as the

crop ripened and was harvested at the end of July. It would appear that the plots of beer sorghum and gram are a potent source of *Lygus* during July, and could contribute to the immigration into May-sown cotton which occurred during that month.

On the Communal Experiment single row plots were laid down for spraying over various periods to estimate the losses of crop caused by insects. One formulation of DDT paste was used, applied as a 0·2% spray to run-off at 7 day intervals. The main spray-periods were (a) August-September, (b) October-November, (c) August-November inclusive, (g) September to November. These periods had been decided on to protect the cotton separately from (a) the bulk of *Lygus* attack; and (b) the bulk of bollworm; treatment (c) was complete protection, and (g) permitted the early attack to go unchecked. The *Lygus* population, and consequent leaf damage, increased during September-November, the peaks varying in the three localities. The populations of bollworms (see below) were so small that the main effects of spraying resulted from control of *Lygus* over different periods of the season.

On the early sowing, the final yields of seed cotton showed that in none of the three areas did complete protection (17 weekly applications of DDT spray) give a significant increase in yield. This treatment of the controls, and bollworm attack measured by flared squares to 2-8% of the controls. In only one of the three areas was a significant increase in yield obtained, and this (at Nalumuli) resulted from the September-November spraying.

The predominant result of this degree of protection was an earlier crop. Highly significant differences in yield were apparent at the 7th picking (out of a total of 13), but by the end of the season the favourable rains had enabled the unsprayed plots to catch up. There were significant negative correlations between yield at the 7th pick, and both leaf-damage index and bollworm index. Because of a strong interaction between these two measures of insect attack, it is not possible to estimate their separate effects on yield. Bollworm populations were, however, too small to be responsible *per se* for the variations in earliness.

On the later sown cotton (August 10), the spray treatments gave the following results:—

(1) In only one of the three localities (Nalumuli) did continuous protection (mid Sept.-mid Dec.) give a significant increase in yield; in this instance an increase of 512 lb. per acre of seed cotton over a control yield of 620 lb. or 82%. In all localities, however, significant reductions were effected in *Lygus* leaf-damage and bollworm damage however, significantly reduced the *Lygus* leaf-damage index to 36-57%

(2) In the other two localities (Namulonge and Kirimantungo) significant increases in yield were obtained by late spraying in November when the bulk of the *Lygus* attack developed on the late sowing.

(3) Spraying again gave an earlier crop, but unprotected plants did not catch up.

(4) In contrast to the early sowing, there was a significant negative correlation ($r^2 = 0{\cdot}71$) between *Lygus* leaf-damage index and final yield.

For the present season therefore the following conclusions emerge. Only on late-sown cotton was *Lygus* damage causing appreciable loss of yield. This may have been excessive on the Communal Experiment where early and late sowings were adjacent, and breeding occurred throughout the season. The main effect of *Lygus* on the earlier sown cotton was to delay the cropping. The best treatments, however, only reduced the *Lygus* leaf damage index to 36% of that on the controls. With complete protection the results might have been different. Steps are being taken to improve the degree of control, but it is worth noting here that in all the experiments conducted, this is the best reduction in attack as measured by leaf damage that has been so far achieved.

The results obtained in this first season of the Communal Experiment have shown from an entomological viewpoint the absolute necessity of continuing such experiments over a number of years, in order to cover the variations of both climatic conditions and levels of insect attack. Already, within the limits of a research station the marked effect of locality is apparent: in this instance causing differences in timing of the insect attack, and rate of maturation of the crop—two factors which could have a great influence on the damaging capacity of an insect such as *Lygus*.

Bollworms.

Observations on the bollworm population in the cotton crop over the past season show that over the whole season only a mean of one bollworm per plant was present. The number of the various bollworms varied through the season. *Heliothis armigera* and *Earias spp.* were present throughout, and constituted the greatest proportion of the population. The peak of the attack appeared at the end of October as 1 per 10 plants. In November the number of *Heliothis* fell by 75% when the maize became attractive. Towards the end of the season *Argyroploce leucotreta* and *Platyedra gossypiella* were found in green bolls, but in equally low numbers.

Argyroploce larvae were found in 44% of all maize cobs examined one month before harvest, at a time when the cotton was also

attractive, but few were found on the cotton. Maize must therefore be more attractive to the moth than cotton, acting in this case as a good trap crop.

With large areas of cotton on Namulonge it is difficult to understand why the bollworm population remains low. Intensive investigations are therefore being carried out on the parasites and predators which attack them, and on their biology with special emphasis on the pupation period.

A light trap has been functioning since the end of the season with the view of trapping night flying moths. *Heliothis* and *Earias* species have been present in the catches.

Plant Pathology

BY

G. M. WICKENS.

Bacterial Blight (*Xanthomonas malvacearum*).

In co-operation with the Government Plant Pathologist seed lots were prepared for the Intermediate Variety Trials reported by the Plant Breeding Section. Seed for one treatment was inoculated with pure cultures of *X. malvacearum*, with special measures to provide not only equal application of inoculum but also equalisation of any natural infestation that may have been carried more in some lots than in others. Seed for the other treatment was dressed with equal applications of the organic mercurial compound Granosan by a standardised method.

In the Namulonge trial, in which independent records were taken, seed dressing did not entirely eliminate seedling infection. At 6 weeks there were found 38 more or less severely infected seedlings in the seed-dressed half of the experiment in a total of about 12,000. These were rogued out, and thereafter the incidence of leaf and stem infection was very light. Later, however, there was an appreciable attack of bacterial boll disease. Unfortunately it was not possible to obtain adequate field records of its incidence in the two halves of the experiment. Later laboratory examination of samples supplied by the Plant Breeding Section showed that staining of picked seed cotton was preponderantly due to *X. malvacearum* and figures for per cent stain may be taken as a reasonable index of relative incidence of bacterial boll disease.

Data on the incidence of early leaf infection and later main stem lesions in the seed-inoculated part of the experiment are summarised in Table 10.

TABLE 10.

ANALYSIS OF INCIDENCE OF BACTERIAL BLIGHT (% OF PLANTS AFFECTED TRANSFORMED TO SIN $^{-1}\sqrt{\%}$) IN THE SEED-INOCULATED PART OF THE NAMULONGE INTERMEDIATE VARIETY TRIAL.

	35-39 days		*53 days*		*77-83 days*			
	Infections true leaves		*Main stem lesions*		*Severe main stem lesions*		*Total main stem lesions*	
	Degrees	%	Degrees	%	Degrees	%	Degrees	%
Albar 615	9·24	2·6	12·60	4·8	13·66	5·6	27·06	20·7
SR 1218	9·36	2·6	7·74	1·8	9·50	2·7	16·70	8·3
SR 1221	10·54	3·3	12·02	4·3	12·60	4·8	20·22	11·9
SR 1245	11·04	3·7	9·98	3·0	18·82	10·4	22·46	14·6
SR 1217	11·14	3·7	10·18	3·1	15·86	7·5	23·02	15·3
SR 1246	12·08	4·4	13·00	5·1	21·76	13·7	25·92	19·1
K 51	15·26	6·9	19·10	10·7	20·18	11·9	25·78	18·9
SR 1243	16·42	8·1	15·12	6·8	31·44	27·2	38·74	39·2
C(51)22	18·86	10·5	18·68	10·3	23·36	15·7	32·62	29·1
C(50)20	19·90	11·6	17·38	8·9	21·88	13·9	31·92	28·0
SR 1244	19·94	11·6	17·82	9·4	29·24	23·9	35·88	34·3
BP52.5MB	21·36	13·3	16·58	8·1	18·32	9·9	28·64	23·0
BP52/6	25·30	18·3	19·88	11·6	21·84	13·8	35·38	35·5
C(51)19	26·16	19·4	20·64	12·4	23·18	15·5	35·04	33·0
Standard error	±1·89		±1·26		±1·63		±1·91	

The order of susceptibility in the several recordings is not consistent. While SR 1218 and SR 1221 showed evidence of high resistance and BP52/6 and C(51)19 of susceptibility in all recordings, others were variable. For example, SR 1243 occupied a middle position in the first two records, but had the highest susceptibility in the last, while conversely BP52.5MB appeared more resistant in the last count than earlier records suggested. No single record from this experiment can therefore be held reliably to express the relative susceptibility of the strains to bacterial blight in general.

This argument is strengthened and widened by consideration of the yield data (see Table 11). The strains giving appreciably higher yields in the seed-dressed part of the experiment than in the seed-inoculated part included not only those showing susceptibility, but also some of those that appeared to show resistance. Two strains, SR 1218 and C(50)20, conspicuously failed to show a favourable yield response to seed protection. The former showed high resistance to main stem attack, but the latter did not. These apparent anomalies are not resolved by the data for incidence of boll attack. Evidently differential response to attack by *X. malvacearum* is of considerable complexity, involving factors additional to those of inherent leaf, stem and boll tissue resistance.

Leaf spray inoculation of 8-week-old SUS 7/2, tagged to indicate the youngest expanding main stem leaf at the time of inoculation, led to angular leaf spot in most of the main stem leaves, which as expected, showed greater resistance with increasing age, although the general levels varied considerably from plant to plant. Vein lesions

developed on 49 of the 155 youngest expanded leaves (at time of inoculation) within three weeks, in only 2 of those next older, and in none of those older still, although within this period angular leaf spots had appeared on leaves even down to the 8th below the youngest expanded. As the plants developed, new main stem leaves became progressively infected with both angular leaf spots and vein lesions, the former usually appearing first. Main stem lesions developed above the node of the youngest expanded leaf, at the time of inoculation, not always immediately above, and sometimes girdled and killed the stem. Leaves and stem tissues of branches also became infected, and the bolls were also attacked.

The severe disease in all phases developing from one spray inoculation was in striking contrast to the very light incidence of all phases except bacterial boll disease in adjoining unsprayed rows. This confirms observations commonly made in the previous seasons, and it is evidently characteristic of local conditions that plant-to-plant spread of all phases of the disease except bacterial boll disease is remarkably limited, even though hard driving rainstorms are not uncommon.

Needle prick inoculations of stems and branches again sometimes induced symptoms of a vascular wilt type, and the vascular nature of the infections has been confirmed. In greenhouse experiments the course of vascular infection in seedlings raised from inoculated seed has been further studied and the natural occurrence of this type of infection in the field confirmed. A paper on this subject is in course of preparation. Much progress has also been made in the development of a sensitive method for detection of *X. malvacearum* in a mixed microflora (as for example in soils) using the host plant as a selective medium, as a prerequisite to study of survival of the organism in natural habitats.

Verticillium Wilt (*V. dahliae*).

The season was remarkable for a low incidence of this disease, and a strong power of recovery in infected plants, not only in those naturally infected but also in inoculated plants of a highly susceptible strain. The reaction of these plants to infection was similar to that of resistant strains in other seasons. No explanation of this abnormal behaviour can as yet be offered.

In a number of experiments, variations of method of inoculation and type of inoculum were tested on susceptible and resistant strains, at different ages. These variations, designed to facilitate large-scale field inoculation in breeding for resistance, as well as more fundamental pathological work, gave under the abnormal conditions promising results.

Plant Breeding

BY

D. MACDONALD AND H. L. MANNING.

Bacterial Blight Resistance.

Compared with the rather dry season of 1952-53, when all the material used in selection for bacterial blight resistance was planted late (August 12th), moisture conditions during the current season enabled all stocks to be planted early (June 10th and 11th) and at no time during its growth and development did the crop suffer from moisture shortage. This enabled useful information to be obtained on the reaction of similar strains when grown in two seasons which differed considerably.

One hundred and twenty-seven selfed single plant selections and nineteen bulks of Albar 51, selected the previous season, were planted on June 10th and stem inoculated by the needle prick technique on August 25th. During the last fortnight of September the individual plants were graded for development of the resulting stem lesions. Of the hundred and twenty-seven progenies, forty-eight were homozygous for resistance to the stem phase of the disease while in another twenty-one, only one plant per progeny was discarded. No progeny had to be discarded for complete susceptibility.

A pleasing feature of the whole Albar 51 group was its good power of recovery from insect damage. *Lygus* attack caused the loss of much early fruit, but when the attack ceased a fresh crop was produced much more rapidly than in adjacent BP52 which suffered a similar attack.

The range of desirable characters besides blight resistance included good fruiting, earliness, high ginning outturn and a wide range of lint lengths, and made possible selections combining stem resistance to bacterial blight with the other important economic characters. Within such variable material it is only natural that in the early stages undesirable characters would also appear. Several progenies were discarded on account of sterility, while one family was uniform for a procumbent habit. Furthermore the range of leaf hairiness is not good, and no plants were found whose length-density combination of leaf hairs was good enough to give resistance to a severe jassid attack.

Final field selections resulted in 366 single plants and 43 special bulks being brought in for laboratory analysis. Lint from 30 of the special bulks has been forwarded to the Shirley Institute for small scale spinning tests. Count × Strength products at 40's were very satisfactory, 25 out of the 30 samples ranging from 1,900 to nearly 2,400. Yarn appearance was also good, and a considerable improvement on that of earlier material.

A preliminary attempt was made to compare boll resistance to bacterial blight in Albar 51/474, which is homozygous for stem

resistance, with that of a BP52 bulk homozygous for stem susceptibility. Inoculating two-day-old bolls was carried out daily by atomisation of a suspension of bacteria into the cup formed by the calyx at the base of the boll. Examination for boll wall lesions before boll opening showed that in the BP52 strain 95% of the surviving bolls had developed lesions whereas in the Albar bulk, only 32% of the bolls were infected.

Seventy-one progenies from fifteen BP52 families showing stem resistance in the previous season were grown and stem inoculated. None were homozygous for stem resistance. Stem inoculation of the progenies was carried out on August 22nd and the first roguing for susceptibility on 22nd September showed many plants to be resistant, when judged by the healing of the wound and callus formation at the point of inoculation. Further examination of the progenies within the following month showed that in many plants on which the wound at the point of inoculation had to outward appearance healed thoroughly the disease had travelled up the vascular system and lesions appeared higher up the stem. This phenomenon was not observed in the Albar 51 progenies but was commonly found in Stoneville 20 crosses and backcrosses. While no progenies in the BP52 group were homozygous for stem resistance, the percentage of resistant plants in many progenies (up to 90% in some cases) showed a marked increase over the previous season. 145 single plant selections covering a range of good characters in addition to stem resistance are being carried forward.

Stoneville 20 crosses proved disappointing, both in blight resistance and in other characters, and were discarded.

F_1s of crosses between Albar 51 selections and a number of MU8 × $BP52^2$ strains were grown and backcrossed. They were grown adjacent to progenies of the susceptible MU8 × $BP52^2$ parents and the difference in resistance to natural infection by bacterial blight in all its phases was striking. Whereas the MU8 × $BP52^2$ progenies suffered severely and yielded only a medium crop, much of it stained, the F_1s produced a heavy crop of clean cotton.

Verticillium Wilt Resistance.

Work on the isolation within the Albar 51 group of strains resistant to *Verticillium* wilt was continued. Having been first stem inoculated with bacterial blight, the resistant plants were later inoculated with *Verticillium* wilt. A range of B181 and B181 × BP50 selections resistant to *Verticillium* were grown as controls and similarly dual inoculated. Resistance to wilt within the Albar 51 progenies was not high compared with the controls and selection for resistance was complicated by the abnormal behaviour of the diseases during the season.

BP52 Modal Bulk.

The history of this standard has been given in previous progress reports. It has, however, undergone a marked change during the past two seasons and is worth considering in some detail. During the past season 6MB was grown. At an appropriate date 200 plants were chosen in the field and their produce brought to the laboratory for the customary analyses. Selection within the range plus or minus one standard deviation was carried out successively for lint index, seed weight and mean maximum halo length. This left 69 plants for bulking to form 7MB. The mean yield of these plants was some 6 per cent better than the mean for the 200 original plants. This change was somewhat unexpected. Originally it was thought that there would be a gradual reduction in yield improvement of successive modal bulks, as indeed there was up to 5MB, which had a cumulative total of what appeared to be about 17 per cent improvement over the original bulk in 1947-48. Since then both 6MB and now 7MB have had mean lint yields each between 5 and 6 per cent better than their preceding generation. When these cumulative increments are plotted they form a cubic relationship which indicates that 7MB should be about 28 per cent better than the original bulk.

Since this standard is used for checking expected yield advances from replicated progeny rows and small bulks trials, it was naturally of great importance to test the various modal bulks against some other standard. Unfortunately in the trial laid out this season, the viability of the earlier stored seed was not as good as that of more recent stocks and the resulting yield comparisons are unreliable. However, the most recent comparison of 5MB against the K/51 or BP52B control shows that there is a real difference of the order of 10 per cent in favour of 5MB, and since K/51 in earlier years has been shown to be about 6 per cent better than original bulk, the expected position of 5MB on the cubic curve—some 17 per cent better than original—may be accepted with confidence. New selfed seed of the range of modal bulks is to be tested during the coming season and will doubtless provide some interesting information.

BP52 Progeny Rows.

Of the 100 progeny rows grown this season, 81 were tested in a 9 × 9 lattice square. These latter included 65 selected according to the previous season's selection index technique. Analyses of variance and co-variance indicated that with a selection differential $z/q = 1{\cdot}596$, the expected genetic advance would amount to 2·3 per cent. Although small, this amount indicates that selection within this material continues to be worth while. Indeed this is borne out by the estimates for "heritability" for the various traits; that for bolls per plant being 0·121, for seeds per boll 0·594, for lint per seed 0·370 and for lint yield

itself, 0·160. Moreover it may be shown that, over the past six seasons during which this technique has been employed, the cumulative yield advance, both in theory and in fact, stands at a very high level. The mean yield of the 9 selected progenies over 6MB amounted to 9·3 per cent. Since 6MB is about 22 per cent better than original bulk, an overall improvement in yield of the order of 30 per cent may be confidently expected. Since one of the earlier selections is later shown to be more than 20 per cent better than BP52B, such an expectation is entirely reasonable.

Small Bulks Trials.

Bulks of the selected progenies from the previous season were grown early and late at each of 3 localities and each with three replications. With 18 effective replications it was thus possible to follow the important variety × locality interactions. Mean lint per acre for the early sown plots (June 4th) amounted to 307 lb. per acre. The late sown (August 11th) had a mean yield of 216 lb. per acre, so that early sown gave an increment of 42 per cent. (Coefficient of variation = 12 per cent). Interactions between strain and locality, and strain and sowing date were of no importance.

The actual yield advance of the 8 small bulks over the 5MB control amounted to 9·6 per cent. Since 5MB may be taken as 17 per cent better than original bulk, this suggests that the C(52) series will be about 27 per cent better than original bulk. The best of these was some 18 per cent better than 5MB, being 38 per cent better at the lowest locality yield level.

Intermediate Variety Trials.

At the suggestion of the then Senior Botanist at Kawanda a new series of trials has been introduced to provide a link between the Small Bulks Trials and the District Variety Trials. These latter, being 5 × 5 latin squares, have necessarily put a limit on the number of promising strains which may be tested. Therefore, it was considered desirable to set up a test of a wide range of material on each of the three experimental stations serving the BP52 area, namely Bukalasa, Namulonge, and Kawanda. The scope of the trials was further widened by including two main treatments. One half of the seed was treated by soaking in a suspension of *Xanthomonas malvacearum* and the other was dusted with Granosan, an organic mercurial bactericide.

Of the 14 lines grown 5 were from Namulonge, including one Albar known to have a high (but not uniform) degree of stem resistance to bacterial blight. Seven others included backcross material from Kawanda and Serere, using in some instances B181 as the donor parent, and others a blight resistant *punctatum*. Finally two standards were

TABLE 11.

INTERMEDIATE VARIETY TRIAL AT THREE LOCALITIES.

CLEAN LINT PER ACRE. LB.

Main treatments (a) Inoculated with *Xanthomonas malvacearum*. (b) Seed dusted with bactericide. Plot size 1/72 acre. Five replications for each treatment at each locality. Overall means of 30 replications.

	(a) *Inoculated*				(b) *Protected*				*Increment*		*Per cent stains for Namulonge only*		*Mean Yields*		
									Due to Prot.				*M.S.L.*		%
	Buk.	*Nam.*	*Kaw.*	*Mean*	*Buk.*	*Nam.*	*Kaw.*	*Mean*	*lb.*	*Per cent*	*Prot.*	*Inoc.*	*inoc.*	*30 reps.*	*K/51*
Albar 615	455	395	325	392	513	466	372	450	58	15	11	19	13·7	421	126
C(50)20	486	427	315	409	502	434	327	421	12	3	6	10	21·9	415	124
C(51)22	444	408	289	381	541	421	333	432	51	13	7	9	23·4	406	121
C(51)19	429	376	262	356	493	420	330	414	58	18	5	13	23·2	385	115
5 MB	424	338	277	346	490	371	311	391	45	12	10	15	18·3	368	110
SR 1218	440	368	254	354	431	355	217	334	*Loss*		8	11	*9·5*	344	103
SR 1217	403	347	222	324	419	358	279	352	28	11	5	14	15·9	338	101
K/51	399	308	227	311	450	334	291	358	47	16	11	12	20·2	335	100
BP52/6	393	300	226	306	427	383	242	351	45	15	10	13	21·8	329	98
SR 1221	378	316	217	304	396	302	313	337	33	15	8	14	12·6	320	95
SR 1244	364	261	199	275	437	351	256	348	73	*28*	11	15	29·2	311	93
SR 1245	388	270	209	289	390	323	267	327	38	17	11	13	18·8	308	92
SR 1246	358	279	178	272	397	324	265	329	57	25	10	14	21·8	300	90
SR 1243	348	252	186	262	406	318	263	329	67	*28*	9	11	*31·4*	295	88
Means	408	332	242	327	449	369	290	369	42	13	8·8	13·0		348 lb.p.a.	
S.E. for Means of 15				14·0				14·9							

included, K/51 and the newer strain BP52/6, which is being multiplied in Bunyoro for the seed renewal scheme. During the season the Plant Pathologist carried out main stem lesion counts on the inoculated plots of the Namulonge part of the experiment. These are summarised in Table 11 as percentages transformed to degrees and appear under the column M.S.L. inoculated.

Table 11 shows that according to the M.S.L. counts three strains SR 1218, SR 1221, and Albar 615 showed a high degree of resistance. Two strains SR 1244 and SR 1243 which, incidentally, were from the *punctatum* donor, showed very high susceptibility. All others showed intermediate susceptibility. It was expected that susceptible strains would yield more in the protected than in the inoculated replicates, whereas resistant strains would yield about the same in both series. In fact, only the most resistant (SR 1218) and a group of the most susceptible strains followed this pattern. Among the rest, the yield increment due to protection for the C(50)20 strain, which is susceptible on M.S.L. counts, amounted to only 3 per cent. By contrast that for Albar, which is resistant on M.S.L. counts, amounted to some 15 per cent. There can be no doubt of the efficiency of inoculation since the percentage of stained cotton in every case was greater on the inoculated than on the protected plots.

There appears to be a form of resistance other than main stem lesion resistance in certain BP52 strains and this has led to significantly different yields of seed cotton from the expectation based solely on main stem lesion resistance. The trial also provided additional evidence that the Namulonge BP52 selections have a material yield advantage over the existing bulks K/51 and BP52. This advantage is more marked under conditions of artificial attack and it may be presumed that with natural infection a strain such as C(50)20 would perform well under field conditions.

District Variety Trials.

This season 3 Namulonge selections were compared against 2 controls at each of 13 centres spread over the BP52 area. The controls were K/51, also known in past seasons as BP52B, and BP52/6 known as BC/66 in one previous series. This latter was included to represent seed now being multiplied at the Bunyoro stage for general release in subsequent years, should this prove to be desirable. It is very satisfactory to record that at 8 of the centres the 5 × 5 latin square designs were sufficiently precise to enable varietal differences to be demonstrated with some confidence. Table 12 shows that both C(50)20 and its descendant C(51)22 were more than 20 per cent better than K/51, itself some 9 per cent better than BP52/6.

TABLE 12.

SUMMARY OF VARIETY TRIALS WITH BP52 SELECTIONS, 1953-54.

CLEAN LINT PER ACRE. LB.

Varieties	*Differences statistically significant.*									*No significant differences*						
	Kalagala August 6	*Bukalasa June 18*	*Kakumiro July 3*	*Namulonge June 9*	*Kawanda June 19*	*Nkozi June 13*	*Namyoya June13*	*Kisagazi June 19*	*Mean Yields of 8*	*Bulindi July 3*	*Bukomero July 10*	*Mukono August 10*	*Kabasanda ?.*	*Kyanamukaka August 18*	*Mean Yields of 13 Trials*	
															Actual	*Weighted*
C(50)20	566	506	338	333	308	298	276	278	362·9=123·1 %	509	454	388	293	106	357·9	347·8
C(51)22	548	558	360	318	259	277	284	273	359·6=122·0 %	504	455	393	239	141	354·5	353·1
C(51)19	531	486	295	267	261	226	243	223	316·5=107·4 %	485	437	385	238	108	321·9	310·0
K/51	515	457	273	244	249	221	199	200	294·7=100 %	493	417	339	251	113	305·4	291·8
BP52/6	448	388	283	231	207	260	169	165	268·9= 91·2 %	456	435	372	234*	116	289·5	271·7
Locality	521	479	310	279	257	256	234	228	320·5	489	439	376	251	117	325·8	
C.V. %	7·7	5·3	10·1	7·8	17·1	20·4	13·6	24·9		9·1	9·3	22·0	20·1	22·6		
L.S.D.	55	35	43	31	60	72	44	78		No significant differences						

*Yield estimated by missing plot technique.

Differences at the remaining 5 centres were of considerably lower precision and must therefore be given less weight. Using the technique of weighting the means according to r/si^2 it is possible to estimate the overall variety means for the 13 localities. In this case the differences between the actual and weighted means is not great, though C(51)22 appears to be about 21 per cent and C(50)20 some 19 per cent better than K/51. It is perhaps of interest to note that this increment of C(50)20 confirms the results of the previous season from the trials for which statistically significant results were obtained.

These strains together with 5MB will form the basis for the first of the multi-line strains to be put out from Namulonge. This, NC/54 as it will be known, is to be multiplied under controlled conditions over the BP52 area and will be available for the Bunyoro stage in 1955-56. Since a seed multiplication scheme for such a large area is necessarily slow, it will not replace existing BP52 in general cultivation for at least another 4 seasons.

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